PhD proposal 2018-2021

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Synthesis of 2-dimensional oxides nanosheets and transfer on substrates to induce subsequent epitaxial growth

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The aim of the *PolyNASH* project is to develop the growth and study of functional oxides on low-cost substrates and to propose a new solution for the integration of complex oxides with multifunctional properties for large surface electronics. Most often, this integration is obtained by epitaxial growth of oxides on relatively expensive single-crystalline substrates, which offer a limited choice of materials and crystallographic orientations. The project will focus on the replacement of these single crystalline substrates by low-cost polycrystalline (as silicon) or amorphous (as glass) substrates, covered by a crystalline template of molecular thickness (oxide nanosheets), that can be used as seed layers to induce epitaxy of complex oxides thin films independently on the bottom substrate material. These 2-dimensional (2D) oxide nanosheets are exceptionally rich in structural diversity.

In this PhD work, the starting materials (lamellar $KCa_2Nb_3O_{10}$, $K_4Nb_6O_{17}$, K_xMnO_2 phases) will be synthesized by solid state reaction, molten salts synthesis or thermal decomposition, and exfoliated in solution to form $Ca_2Nb_3O_{10}^-$, $K_2Nb_6O_{17}^{2-}$ and $MnO_2^{0.4-}$ 2D-nanosheets in order to study different crystallographic families of functional oxides [1]. These materials have three different 2D crystallographic lattices, *i.e.* a square lattice, a rectangular lattice, and a hexagonal lattice, and can be used as seed layers for the growth of cubic, orthorhombic and hexagonal phases, as perovskites, garnets and ilmenites. The nanosheets will then be transferred on different low-cost substrates. For the assembly of nanosheets on substrate, Langmuir-Blodgett deposition (*cf*. video on Jove [2]) and electrostatic sequential adsorption by dip-coating will be used by taking advantage of the charged feature of the nanosheets. The different obtained materials will be characterized by X-ray diffraction, energy-dispersive X-ray spectroscopy, scanning electron microscopy, transmission electron microscopy, optical microscopy, atomic force microscopy. As a perspective, complex oxide thin films will be grown on the covered substrates mainly by chemical solution deposition, and possibly by pulsed laser ablation and sputtering techniques.

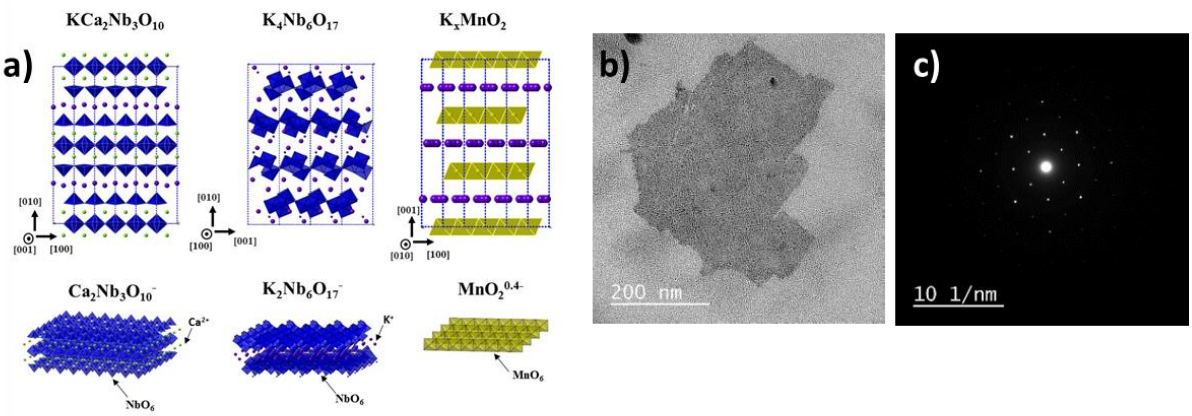

Figure. a) Structures of lamellar phases and of nanosheets resulting of the exfoliation. b) Transmission electron micrograph of a $Ca_2Nb_3O_{10}^-$ nanosheet. c) Corresponding electron diffraction pattern.

[1] *Preparation of niobium based oxynitride nanosheets by exfoliation of Ruddlesden-Popper phase precursor*
A. Maia, F. Cheviré, V. Demange, V. Bouquet, *et al*. Solid State Sci. **54** (2016) 17-21
[2] *Atomically Defined Templates for Epitaxial Growth of Complex Oxide Thin Films*.
A.P. Dral, *et al*. *J. Vis. Exp.* (94), e52209, doi:10.3791/52209 (2014). URL: http://www.jove.com/video/52209

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